OVERCOMING OBSTACLES TO SEDIMENT REMEDIATION in the Great Lakes Basin

White Paper by the
Sediment Priority Action Committee
Great Lakes Water Quality Board
International Joint Commission

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REFACE

he International Joint Commission (IJC) identified "Remediation and management of sediments contaminated ith persistent toxic substances" as one of its 1995-1997 program priorities. Initially, the IJC requested the Water uality Board (WQB), with assistance from the Science Advisory Board (SAB) and Council of Great Lakes esearch Managers (CGLRM), make an assessment of government activities and programs, and identify available ptions and technologies for remediation, destruction, and storage of persistent toxic substances that are located in ontaminated sediment. Consideration should be given to methods of funding and public acceptance of approaches. his issue was identified as a major consideration in Remedial Action Plans (RAPs) and Lakewide Management lans (LaMPs). The IJC requested that a draft report be prepared in the first year which would form the basis for a orkshop in the second year.

QB, with representatives from the SAB and CGLRM, convened a scoping meeting in March 1996 to ine the breadth of the issues to be examined. Specifically, this scoping meeting was charged with ining whether or not there was a value-added role for the WQB and IJC in moving forward on the inated sediment issue and, if so, scoping out the nature of that contribution, the deliverables, the need for a op or working meetings, etc.

sult of the March 1996 scoping meeting, it was proposed that a sediment white paper be prepared in the first hich summarized the contaminated sediment problem, specified key obstacles, and identified options to these obstacles. The sediment white paper would then serve as the basis for a workshop which was held in 997. This approach to the sediment priority was presented and endorsed by the IJC at its April 1996 Semi- Meeting in Washington, D.C. It is recognized that there are undoubtedly other aspects of the contaminated nt issue which require further investigation and should be addressed in the future.

ODUCTION

s a consensus among diverse sectors in the Great Lakes Basin (e.g., government, industry, nongovernmental zations, Remedial Action Plan groups) that contaminated sediment is a major cause of environmental ms and a key factor in many of the impairments to beneficial uses of the Great Lakes. All 42 Great Lakes of Concern have contaminated sediment based on application of chemical guidelines. This universal obstacle ronmental recovery in Areas of Concern can potentially pose a challenge to restoring 11 of the 14 beneficial pairments identified in the Great Lakes Water Quality Agreement (Table 1). Adequate knowledge of impact ntial for determining the degree of impairment. A variety of remedial options are available, ranging from control and natural recovery to full-scale remediation depending on the severity of the problem. Further, it is that some of these concentrated deposits of contaminated sediment be addressed relatively quickly, because me they may be transported from a river or harbor to the Great Lakes. Once dispersed into the lakes, cleanup ally impossible.

ninated sediment is a major problem being addressed in Remedial Action Plans) and Lakewide Management Plans (LaMPs), and is known to be an issue in reas of the Great Lakes Basin. In recognition of the scope of this problem and ited progress in managing contaminated sediment, the International Joint ission (IJC) identified contaminated sediment as a priority for the 1995-1997 l cycle. Further, the IJC assigned this priority to the Great Lakes Water y Board and asked it to review the magnitude of the contaminated sediment m and make recommendations to overcome major obstacles to sediment ation. The purpose of this white paper is to summarize the contaminated nt problem, specify key obstacles, identify options to address the key es, and present workshop recommendations regarding value-added utions the IJC could make to help address current obstacles to sediment ation.

All 42 Great Lakes Areas of Concern have contaminated sediment based on application of chemical guidelines.

IS CONTAMINATED SEDIMENT A PROBLEM?

ninated sediment has been identified as a source of ecological impacts throughout the basin. While inated sediment is not designated as a specific impairment in Annex 2 of the Great Lakes Water Quality nent, in-place pollutants potentially pose a challenge to restoring 11 of the 14 use impairments (Table 1). The phical areas which have received the greatest attention and level of evaluation are the Areas of Concern for RAPs have been developed. RAPs have identified desired future states for the Areas of Concern, which a healthy sustainable environment that supports a balance between ecosystem and economic health. ninated sediment is a major factor limiting the ability to attain these goals. Fish consumption advisories ely affect sport and commercial fishing industries. Contaminated sediment threatens the viability of many rcial ports because of restrictions on dredging of navigational channels and disposal of the dredged nts. For example, in Green Bay, Wisconsin, the viability of the port for inter-lake and international cargo

shipments is at risk due to the delays and expense associated with the management of the contaminated sediment. Municipalities and industries are also faced with increased costs of treating water drawn from the contaminated areas.

Table 1 **- A summary of use impairments potentially associated with contaminated sediment and the numbers of Areas of Concern with such use impairments.**

USE IMPAIRMENT	HOW CONTAMINATED SEDIMENT MAY AFFECT USE IMPAIRMENT	NUMBER OF AREAS OF CONCERN WITH THE IMPAIRED USE (N=42; % in parentheses)
Restrictions on fish and wildlife consumption	Contaminant uptake via contact with sediment or through food web	36 (86%)
Degradation of fish and wildlife populations	Contaminant degradation of habitat; contaminant impacts through direct sediment contact; food web uptake	30 (71%)
Fish tumors or other deformities	Contaminant transfer via contact with sediment or through food web; possible metabolism to carcinogenic or more carcinogenic compounds	20 (48%)
Bird or animal deformities or reproduction problems	Contaminant degradation of habitat; contaminant impacts through direct sediment contact; food web uptake	14 (33%)
Degradation of benthos	Contact; ingestion of toxic contaminants; nutrient enrichment leading to a shift in species composition and structure, due to oxygen depletion	35 (83%)
Restrictions on dredging activities	Restrictions on disposal in open water due to contaminants and nutrients, and their potential impacts on biota	36 (86%)
Eutrophication or undesirable algae	Nutrient recycling from temporary sediment sink	21 (50%)
Degradation of aesthetics	Resuspension of solids and increased turbidity; odors associated with anoxia	25 (60%)
Added costs to agriculture or industry	Resuspended solids; presence of toxic substances and nutrients	7 (17%)
Degradation of phytoplankton or zooplankton populations	Toxic contaminant release; resuspension of solids and adsorbed contaminants, and subsequent ingestion	10 (24%)
Loss of fish and wildlife habitat	Toxicity to critical life history stages; degradation of spawning and nursery grounds due to siltation	34 (81%)

Sediment also plays an important role in the physical movement, chemical partitioning, and biological fate of metals, trace organic pollutants, and nutrients. Heavy metals, many of the more commonly detected toxic organic chemicals, and nutrients are often closely associated with both suspended solids and bottom sediment. Furthermore, many contaminants have a low solubility in water and thus are found in concentrations several orders of magnitude higher in association with sediment particles. Fine-grained sediment has the potential for collecting the highest concentrations of contaminants. This sediment accumulates in low energy areas such as near shore embayments, river mouths, and harbors. Many of these areas are also recipients of urban, industrial and agricultural inputs of contaminants and require periodic dredging for navigational purposes. Over the five year period, from 1985 to 1989, over 15 million m^3 were dredged for navigational purposes throughout the Great Lakes. Fifty-one per cent of this, or approximately 8 million m^3, had to be placed in some form of confined disposal facility due to high

minant levels or because of a standing policy or regulation. This represents a significant increase in cost to gation and associated commerce, as a result of other forms of disposal or reuse being precluded (Allan 1984; rman *et al.* 1983; Reynoldson *et al.* 1988; Zarull and Reynoldson, 1992; IJC 1991). For example, the costs iated with dredging and open water disposal are estimated to be $3-10 U.S. per cubic yard, while the costs iated with dredging and confinement are estimated to be $10-50 U.S. per cubic yard.

najor environmental concern regarding contaminated sediment is the expression of impairment in biota, ding humans. Impacts with direct links to sediment contaminants have been demonstrated for fish and benthic tebrates. Information directly linking sediment contaminants with impacts on humans is sparse compared with vectors such as air, water, and food. Since benthic organisms are a major food source for other ecologically commercially important trophic levels, reductions in or changes to the benthos are of concern. As well, their e of persistent bioaccumulating substances and subsequent transfer to these trophic levels is also of concern. larly, other organisms such as bottom fish, which come into contact with the sediment, show effects including erous lesions. Concern has also been expressed regarding effects, including cancers, of toxic sediments on ns consuming fish from contaminated areas or engaging in water-contact activities (Swartz *et al.* 1985; man 1988; Malins *et al.* 1984; Bauman and Harshbarger, 1985; Mix 1986; Becker *et al.* 1987; Black 1983).

ical resuspension, along with biologically and geochemically mediated processes at the sediment-water face, can substantially prolong the time during which sediment-associated contaminants remain bioavailable ccumulate in the food chain. Once buried in the deep sediment (below 10 cm) particles are often considered as o the system; however, two processes can result in the physical transport of contaminants back into the water nn. Bioturbation, resulting from the activity of benthic invertebrates, can recycle material from as deep as 40 the more active surface layer, thereby keeping contaminants circulating in the ecosystem much longer. The nd process affecting the physical movement of contaminated sediment is their periodic resuspension by major events, internal waves, currents, and vessel traffic. Studies have shown that significant mass loadings of minants can be transported from a river into the lake during high flow events (Cardenas and Lick, 1996). ment from the near shore eventually accumulates in the deep lake basins or moves through the St. Lawrence to the Atlantic Ocean (Allan 1984; Sorokin 1966; Karickhoff and Morris, 1985). This potential for long-term sure of organisms, along with significant local impacts which can be associated with contaminated sediment, ests that intervention (i.e., sediment remediation) is one option. Another option is the "no action native" (i.e., source control and natural recovery).

e are a number of economic concerns related to the presence and possible cleanup of contaminated sediment. potential and real costs must be considered, including: costs to navigation; costs of construction, monitoring, naintaining secure dredge disposal facilities for sediment ranging from marginally contaminated to highly ; costs of specialized and/or long-distance transport of dredged material to a disposal site; and costs associated loss of commerce while waiting for sampling and analysis, rulings, the approval of an existing disposal ty, or the construction of a new one. In addition, other costs can include: the loss of property values in both ent shoreline and water lots; the loss or deferral of development investment; the loss or depreciation of nercial value such as a contaminated fishery; the loss of income from such things as tourism and recreation; he loss of existing capital investment, such as contaminated recreational sites like swimming areas and small marinas.

costs of contaminated sediment cleanup are seemingly more straightforward; however, the questions of how must be cleaned up and by what method, need to be answered very precisely. In addition, the costs of cleanup uite situation-dependent. Just as the actual costs of having contaminated sediment are sometimes difficult to tify, so too are the benefits accrued as a result of cleanup. Therefore, before either a cost-benefit analysis can rformed, or a cost-effective solution chosen, considerably more work will have to be done to quantify and ss these unknowns.

many other issues in the Great Lakes, contaminated sediment is a complex of legal, economic, social, ological, scientific, and ecological issues. In order to achieve progress and ultimately closure, it is imperative he key issues and obstacles be identified and that solutions, possibly site-specific ones, be implemented.

C INVOLVEMENT IN CONTAMINATED SEDIMENT IN THE GREAT LAKES

ıce the signing of the 1972 Great Lakes Water Quality Agreement, the IJC has been intimately and regularly volved in the issues relating to contaminated sediment. The IJC has provided guidance and assistance to the rties, as well as performing their evaluative roll on Parties activities and programs. The continued involvement of IJC has enabled the development and implementation of several significant programs and actions to address ntaminated sediment.

ortly after the signing of the 1972 Great Lakes Water Quality Agreement, the International Working Group on Abatement and Control of Pollution from Dredging Activities was formed. In their report of 1975, they ncluded that the potential impacts from dredging could be significant. They recommended that a binational Great kes register of dredging activities be established and that a common means of assessing sediment contamination established. Shortly after, the IJC's Research Advisory Board Expert Committee on Engineering and chnological Aspects of Dredging was established to look at the use of Confined Disposal Facilities (CDFs) for ntaminated dredge spoils. This work led to the wider development and use of CDFs as a more environmentally und means of dealing with contaminated sediment.

ıe signing of the 1978 Great Lakes Water Quality Agreement prescribed the formation of a Dredging bcommittee, reporting to the Great Lakes Water Quality Board. This group was responsible for the establishment d publication of the first (and subsequent) binational Great Lakes dredging register, which has provided a nsiderable degree of public information on sediment contamination, dredging projects and the disposal/reuse of edge spoils. This group also spent considerable effort looking at the comparability of the different ways sediment ntamination was assessed in Canada and the United States. As a result of this work, and an ecosystem focus lled for in the 1978 Agreement, the Science Advisory Board (formerly, the Research Advisory Board) established Contaminated Sediment Task Force to look at the assessment and potential remediation of contaminated diment, beyond navigational dredging interest. This group expanded the examination of the problem and potential lutions beyond the Great Lakes, to involve experts from many other countries. Meanwhile, the Water Quality oard, taking a closer look at monitoring and surveillance in Areas of Concern, produced a guidance document that cluded a more detailed assessment of contaminated sediment and incorporated much of the earlier work of the ience Advisory Board Task Force.

1986, the terms of reference for the Dredging Subcommittee were expanded to include a responsibility for non-vigational sediments, which led to the subsequent formation of the Sediment Work Group. This group remained ry active over a number of years and produced several documents on sediment assessment and remediation. They so became intimately involved with RAP efforts, making several site visits and sponsoring symposia of ternational experts to: evaluate progress; provide advice and direction; and transfer techniques and technology to e RAP program.

1995, among its many and significant priorities, the IJC directed the establishment of the Sediment Priority ction Committee to: examine the Parties progress in managing contaminated sediment; identify the obstacles maining to resolving any remaining problems; and identify the "value-added role" of the Commission in the issue.

ıroughout the course of its involvement in contaminated sediment issues, the IJC has provided considerable alue-added" benefit to the Parties and the public at large. The establishment of a binational dredging register gave e public, and each Party, easy access to a considerable body of information. The meetings, reports and volvement of its many technical committees and task forces provided both thought provoking information and derstanding to the public. This also provided the basis of several public forums and an unbiased, authoritative cus on the issues. The work of these committees also facilitated international cooperation and technology transfer, well as a continued binational focus on a regionally significant problem. In total, the work of the Commission d its technical committees has significantly influenced and assisted the Parties' efforts related to contaminated diment in the Great Lakes.

BSTACLES TO PROGRESS AND SELECTED EXAMPLES OF OVERCOMING OBSTACLES

ress in sediment remediation has been slow for several reasons. These range from the inability to: define the nt of the problem or the source of the problem; develop a strategy to address the problem; define the clean-up lard; and/or acquire the funding or partners to accomplish the clean-up. Science and technology utilized for nent remediation oftentimes are a modification of established technologies in other aquatic and terrestrial ronments (e.g., soil treatment technologies). Modifications to those techniques, along with increased cation costs and insufficient verification of effectiveness, slow the further application of those techniques to locations.

e is also no single measure of success. Rather, success is measured on a site-specific basis. This in itself nts a challenge for those who may choose to enter into a partnership agreement for cleanup. Success should be ed as the degree to which the environmental or ecological impact of contaminants from sediment have been ced or eliminated. Certainly there can be and has been progress in advancing projects toward remediation, ever, implementation is the only step that results in progress toward restoration of the ecosystem. The ssment of success should also recognize whether the "local" goals and uses of the area are achieved. Further, is a need for public acceptance of a step-wise, incremental approach to agement of contaminated sediment and restoration of beneficial uses, since plete rehabilitation will require a long-term effort.

nce can dictate the state of the sediment quality, while socioeconomic and ical forces will govern the final clean-up targets. Success should include mental gains in environmental recovery of the system and extensive public cipation in the decision-making process.

ssist in developing a broad-based understanding of this complex problem, major acles to sediment remediation have been identified and grouped into the wing six categories: limited funding and resources; regulatory complexity; lack decision-making framework; limited corporate involvement; insufficient research echnology development; and limited public and local support. Presented below brief discussion of each category of obstacle.

There is a need for public acceptance of a step-wise incremental approach to management of contaminated sediment and restoration of beneficial uses.

ted Funding and Resources

ling has been a perennial problem for many RAPs (Appendix 1), and the subject of a recent IJC workshop. s have sometimes been characterized as being in one of two classes: the "haves" or the "have nots." Many s are unable to secure even the base level of funding necessary to support state/provincial coordination and ic Advisory Committee (PAC) functions. The ability to secure funding for sediment remediation is especially lematic as this is often one of the largest single costs associated with RAP implementation.

e U.S., virtually all of the sediment remediation completed to date has been funded as a result of enforcement ns taken against polluters, typically industries or municipalities (Appendix 1). This includes voluntary diation taken under the threat of enforcement. Although Superfund has been responsible for most of the nent remediation conducted in the U.S. (e.g., Waukegan Harbor, Illinois; Massena, New York), enforcement ns have been successful under other regulatory authorities (e.g., Black River, Ohio). The State of Wisconsin is cating a voluntary approach to sediment remediation through the Fox River Coalition. A voluntary approach is y to be most successful where the threat of litigation is lurking.

ever, limited funding is not always a barrier to sediment remediation. Sediment remediation can be mplished as part of a larger ecosystem restoration project. An example of such a project is occurring in the vaukee River Area of Concern where the removal of the North Avenue Dam is restoring the Milwaukee River free-flowing stream for anadromous fish populations and removing contaminated sediment from the aquatic ystem.

ntrast to the U.S., enforcement has not been as significant a source of funding for sediment remediation in

ada. Canada has no direct counterpart to the Superfund Program, and the threat of litigation is not as great an ntive to voluntary action as in the U.S. Most of the sediment remediation conducted in Canada, including the land River and Collingwood Harbour, has been conducted through partnerships developed by the RAP with the ral Great Lakes 2000 Cleanup Fund, a multi-year program that has sponsored studies, demonstration projects, full-scale remediation with industries and other partners.

ding opportunities for some Areas of Concern with contaminated sediment may become even more limited. orcement-funded remediation has been completed at many of the sites where the evidence against the polluter(s) overwhelming. At many of the U.S. Areas of Concern having contaminated sediment, there is no "smoking " to link the contamination with any polluter and enforcement may not be a viable source of funding. Without rcement, or the threat of it, there is no source of funding capable of addressing the costs associated with large- e remediation of sediment at U.S. Areas of Concern. With the termination of the federal Great Lakes 2000 nup Fund in several years, the principal source of funding for sediment remediation at Canadian AOCs appears ertain.

ulatory Complexity

regulatory maze for dredging, treatment, and disposal of contaminated sediment is a significant obstacle to edial efforts in the U.S. (Appendix 1). Numerous federal and state environmental laws, with separate, and etimes conflicting reporting and permitting requirements, may be applied to a sediment remediation project. e of these laws, such as the Resource Conservation and Recovery Act (RCRA) and Toxic Substances Control (TSCA), were developed for control of solid wastes and industrial processes, and are difficult to apply to large mes of dredged sediment which contain substantial amounts of water.

n attempt to streamline the regulatory process, the U.S. Environmental Protection Agency (EPA) - Region 5 and consin Department of Natural Resources have worked together to develop a method for State-approved TSCA nitting for disposal of PCB-contaminated sediments to licensed landfills. The U.S. EPA - Region 5 also recently pleted a guidance document on design of confined disposal facilities for contaminated sediment that addresses RA and TSCA concerns.

anada, major sediment remediation projects have been the result of public-private partnerships (Appendix 1). e of the greatest progress has been made where, with or without the threat of legal action, administrative ibility and negotiation on cleanup levels have been used to achieve progress toward ecological restoration.

k of a Decision-Making Framework

le the most urgent need in environmental management is to protect the ecosystem from further abuse apart from rce control, the levels and rates for cleanup are not addressed in current sediment guidelines or criteria. isions to cleanup contaminated sediment depend on a large number of variables, one of which is sound science. ientific framework for evaluating the ecological significance of contaminants in sediment, however, is lacking. al decision-making has been hampered by lack of guidance on defining quantitatively acceptable or cceptable conditions. Also lacking is a method for integrating a large number of environmental measurements. at is needed is a pragmatic decision-making framework that leads to the selection of ecosystem- and cost- ctive options for management of contaminated sediment.

progress from a contaminated sediment problem to the restoration of beneficial uses in an area will require a tegy that involves a phased approach, likely over several years, to achieve significant improvements. It is erative that any active intervention for sediment management beyond source control be aimed at use restoration, ed on the weight of evidence of the biological data that demonstrates action other than natural recovery is essary. A realistic schedule should allow sufficient time for source controls to take effect. The strategy must ect the practical constraints of sediment remediation technologies.

ediment remediation strategy based upon biological effects was used to govern the sediment cleanup in

lingwood Harbour, Lake Huron. Where chemical guidelines were exceeded, biological information was ıered. Given the variety of possible responses of biota to the test sediment, the RAP used the absence of lethality aboratory assays and/or the absence of severely impaired benthos to be the minimum criteria for sediment ınup. A higher level of cleanup was selected by the PAC and the target achieved was the absence of chronic cts in the laboratory and presence of benthic communities comparable to reference conditions. The zones for iment removal were mapped by biological endpoints. Following remediation in some zones of the harbour, als in sediment did remain in excess of provincial guidelines. These metals were not bioavailable and were efore left in place. A monitoring program to track recovery of the benthos is in place.

ıited Corporate Involvement

torically in the U.S., corporations have only been involved in sediment cleanup under the threat of litigation. wever, there are promising initiatives like the Ashtabula River Partnership in Ohio and the Fox River Coalition Visconsin which have substantial corporate involvement and support (Appendix 1). Such experiences must be luated and shared elsewhere. In some instances, corporations seek independent parties to which they can tribute funding towards cleanup, however, such vehicles are rare. There is a need for greater corporate olvement in cooperative, cost-effective efforts to remediate contaminated sediment. Further, there is a need for earch into mechanisms to facilitate these partnerships.

ufficient Research and Technology Development

nough many aspects of research and development have been advanced through Environment Canada's Great es Programs and U.S. EPA's Assessment and Remediation of Contaminated Sediments and Superfund ovative Technology Evaluation Programs, knowledge, in a number of areas, will need to be advanced before or progress can be achieved. Some of the key areas for research and development work include:

- accurate physical identification and differentiation of sediment deposits, which will allow both cost-effective assessments and clean-ups;
- a better understanding of chemical fate, distribution and behaviour to assess existing and future potential risk;
- further toxicity testing methodology development and standardization to provide integrated, defensible and efficient techniques of assessment;
- a greater understanding of the ecological impacts and implications of low-level bioaccumulation, lab toxicity test results, community shifts and species losses as a result of exposure to contaminated sediment; and
- the integration of physical, chemical, toxicological and ecological results into a decision-making framework.

ther work is also necessary on the implications and linkages of sediment contamination to human health (e.g., tes of exposure, long-term exposure effects, etc.), the economic and social costs and benefits of having and ıning up contaminated sediment and the development and demonstration of environmentally and economically t-effective technologies.

ıited Public and Local Support

ce contaminated sediment is an "invisible" problem, it is more difficult to build public support for this type of blem than some other more obvious environmental problems. Moreover, there can be a number of reasons for a k of public support, including:

- lack of understanding that contaminated sediment is contributing to environmental impairments;
- lack of consensus on alternative remedial options such as: dredge and treat; dredge and place in confined disposal facilities; in-situ treatment; or natural recovery (no action alternative); and
- disillusionment due to slow progress in achieving cleanup (due to shortage of funds; delays due to legal negotiations; delays due to lack of industrial cooperation).

re is no doubt that strong public and local support is essential to sediment project implementation. There is

strong agreement that the RAP process is an effective tool to gain public and local support for sediment remediation. RAPs offer a consensus-based, multi-stakeholder approach to build public support and understanding. The most successful example of this has been through the Collingwood Harbour RAP where stakeholders were equal partners in problem identification, goal setting, review of options, and selection of remedial actions for removal of contaminated sediment and restoring uses. Such success stories need to be shared and encouraged elsewhere. Based on the Collingwood Harbour RAP experience, it is important for RAPs to communicate complex data bases in plain language. This will help provide the necessary tools to help the public select and lobby for preferred remedial options.

OPTIONS TO ADDRESS OBSTACLES

If significant progress is to be made in restoring ecosystem integrity in Areas of Concern and other areas throughout the basin, then substantially greater progress must be made in overcoming obstacles in order to advance the management and cleanup of contaminated sediment. Presented in Table 2 are some preliminary options for IJC actions to address the six categories of obstacles.

Within each category of obstacle, options to address obstacles were identified as either high priority or lower priority ones. The Sediment Priority Action Committee first evaluated the probability of success (i.e., the chances of the IJC action achieving positive, intended results) and potential payback (i.e., the degree to which this particular action would address the obstacle) for each of the options. Only options which received a medium or high ranking in both probability of success and potential for payback were placed into the high priority option category. Based on this evaluation by the Sediment Priority Action Committee, a total of 15 high priority options were identified to address the six categories of obstacles to sediment remediation. It was also recognized by the Sediment Priority Action Committee that there are linkages among the options and a group of two or three related options may have an improved probability of success or produce higher returns if done in concert.

The primary intent of this exercise was to identify potential IJC options to address known obstacles to sediment remediation in the Great Lakes Basin. This information was compiled as background material for a June 1997 workshop. It is also hoped that this information will enhance broad-based understanding and support for moving forward on pragmatic management of contaminated sediment.

Table 2 **- A summary of IJC options to address obstacles to sediment remediation and management.**

LIMITED FUNDING AND RESOURCES

	Option	Probability of Success	Potential Payback
High Priority Options	IJC could recommend that the Parties establish a sediment "swat team" to pool resources in order to address sediments throughout the basin	Medium	Medium
	IJC could facilitate the establishment of local sediment cleanup trusts or foundations	Medium	High
	IJC could serve as a clearing house on successful funding mechanisms and cost avoidance strategies	High	Medium
Lower Priority Options	IJC could become an advocate for ensuring adequate federal and jurisdictional funding in order to leverage other funding and attract other cleanup partners	Low	High
	IJC could recommend that the Parties and Jurisdictions ensure that adequate technical staff are available to support local sediment management initiatives	Low	Medium

REGULATORY COMPLEXITY

	Option	Probability of Success	Potential Payback
ligh iority tions	IJC could recommend that the Parties and Jurisdictions modify existing sediment management programs to allow for a step-wise approach to management of contaminated sediment	Medium	High
ower iority tions	IJC could recommend that the Parties and Jurisdictions establish a sediment ombudsman to help overcome regulatory obstacles and move projects forward	Low	Medium
	In the absence of a change in regulatory structures, IJC could advocate use of maximum flexibility in use of regulatory tools	Low	Medium
	IJC could recommend that the Parties and Jurisdictions modify existing laws to facilitate sediment remediation and management	Low	High

LACK OF A DECISION-MAKING FRAMEWORK

	Option	Probability of Success	Potential Payback
ligh iority tions	IJC could recognize and advocate use of a step-wise and incremental approach to sediment remediation within the RAP process	High	Medium
	IJC could advocate that the Parties develop consistent sediment management decision-making frameworks that logically guide community-based decisions on sediments (i.e., scientifically defensible and publicly acceptable)	Medium	Medium

LIMITED CORPORATE INVOLVEMENT

	Option	Probability of Success	Potential Payback
ligh iority tions	IJC could attract corporate interest by assembling and disseminating information on economic and environmental benefits of sediment remediation	Medium	Medium
	IJC could encourage Council of Great Lakes Industries or other industrial groups to become more actively involved in RAPs and sediment remediation	Medium	Medium
ower iority tions	IJC could approach industries and corporations, and encourage them to move forward on innovative, cost-effective sediment remediation	Low	High

INSUFFICIENT RESEARCH AND TECHNOLOGY DEVELOPMENT

	Option	Probability of Success	Potential Payback
igh iority tions	IJC could recommend that the Parties and Jurisdictions develop methodologies to quantify ecosystem and economic benefits from sediment remediation	Medium	Medium
	IJC could recommend that the Parties promote reclaiming material from confined disposal facilities via research and demonstration projects	Medium	High
wer iority tions	IJC should recommend that the Parties sustain adequate funding for focussed sediment research and cost-effective technology development	Low	Medium

LIMITED PUBLIC AND LOCAL SUPPORT

	Option	Probability of Success	Potential Payback
High Priority Options	IJC could be a champion and celebrate successes (including partial ones)	High	Medium
	IJC could research and disseminate use of covenants or other agreements between industries and local communities to commit to sediment remediation and management	High	Medium
	Commissioners could be vocal advocates for the sediment issue at both the basin-wide level and at local RAP meetings	High	Medium
	IJC could use multimedia mechanisms for sharing sediment management experiences and successful RAP processes	High	Medium
	IJC could convene one of its binational public meetings in 1997 on contaminated sediment to enhance public understanding and support for remediation	High	Medium
Lower Priority Options	IJC could encourage continued use of cooperative, multi-stakeholder decision-making processes within and outside of Areas of Concern	Low	Medium

OUTPUT FROM JUNE 1997 WORKSHOP

On June 18, 1997 a workshop entitled "Identifying the Value-Added Role of the IJC in Overcoming Obstacles to Sediment Remediation in the Great Lakes Basin" was convened in Collingwood, Ontario. Approximately 35 individuals participated, including representatives from WQB, SAB, Council, and SedPAC, and two Commissioners.

In general, workshop participants concurred with the categories of obstacles to sediment remediation that were identified in the white paper. Two breakout groups were then used in the workshop to identify the two or three most important IJC options to help overcome obstacles to sediment remediation. It was felt that incentives to corporate involvement are generally weak and poorly articulated, and that in most areas there is limited public and local support for sediment remediation. In addition, lack of a consistent but flexible decision-making framework continues to confound and frustrate RAP processes and other local sediment initiatives.

Workshop participants recommended two very important, value-added contributions IJC could make to help address current obstacles to sediment remediation:

- compile and disseminate information on the economic and environmental benefits of sediment remediation; and
- develop guidance for making decisions regarding management of contaminated sediment.

Workshop participants also noted a number of other options IJC may want to pursue depending upon time and resource availability. These include:

- Commissioners could be opportunistic advocates for sediment funding and legislation (e.g. through Hamilton Harbour Status Assessment);
- IJC could recommend in its Biennial Report that the Parties and jurisdictions provide adequate staff to support sediment remediation efforts; and
- IJC could prepare materials and launch a binational marketing campaign that would address the importance of contaminated sediment management.

SedPAC reviewed the two primary workshop recommendations and has proposed action plans for IJC's 1997-99 cycle to address each recommendation (Tables 3 and 4). Specifically, these action plans lay out a series of

nplementary activities that could be taken by IJC and other organizations to help overcome obstacles to sediment nagement. WQB will be addressing these workshop recommendations during the 1997-1999 biennial cycle.

***ble 3* - An action plan proposed by SedPAC to utilize benefits assessment to help promote implementation ediment management actions.**

Activity	Mechanism	Timeframe	Responsible Party
mpile methodologies to antify environmental and onomic benefits	Great Lakes Economic Valuation Guidebook	Initiate: fall 1997 Duration: 6-9 months	Northeast Midwest Institute in consultation with SedPAC
view methodologies and tain feedback on engths and weaknesses	Stakeholder Forum	Spring 1998	Northeast Midwest Institute and IJC co-sponsorship of Stakeholder Forum
ply methodologies in at st one U.S. and one nadian Area of Concern	Case Studies	Initiate: January 1998 Duration: 12-18 months	WQB/SedPAC in cooperation with Parties and jurisdictions
epare summary report ich provides guidance applying methodologies d presents key findings m case studies	Summary report, home page, Commissioner and IJC staff presentations	Initiate: summer 1999	SedPAC and IJC staff
leverage implementors funding, resources and orities	Meetings with senior management and industry; legislative briefings	Initiate: immediately	Commissioners and IJC staff

***ble 4* - An action plan proposed by SedPAC to encourage use of compatible decision-making frameworks management of contaminated sediment.**

Activity	Mechanism	Timeframe	Responsible Party
mpile information on evant sediment decision-king frameworks	Summary document	Initiate - immediately Duration - 9 months	SedPAC
cure support from rties/jurisdictions for veloping guidance on cision-making meworks	WQB members ensure support from Parties/jurisdictions	Initiate - immediately Duration - ongoing	WQB members
velop guidance for national approach for cision-making	Binational workshop to strive for consistent/compatible approaches	Initiate - fall 1998 Duration - 6 months	SedPAC and Parties in cooperation with SAB and Council
st, validate and finalize set of decision-making meworks (pilot testing)	Summary report and binational forum	Initiate - spring 1999 Duration - 6 months	Parties and jurisdictions in cooperation with WQB
vocate use of nsistent/flexible decision king frameworks	Distribution of information through reports, home pages, meetings with senior management	Initiate - spring 1999 Duration - ongoing	Commissioners, WQB members, and IJC staff

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APPENDIX 1

A Summary of Sediment Management Actions
and Obstacles
in Great Lakes Areas of Concern

A *A breakdown of sediment remediation projects in Great Lakes Areas of Concern.*

B *A summary of the status of contaminated sediment management actions in Great Lakes Areas of Concern (1997).*

C *A summary of contaminated sediment management actions taken in Great Lakes Areas of Concern, with identification of major obstacles to further action.*

D *Preliminary assessment of obstacles to sediment remediation based on input from local, state, provincial, and federal officials.*

4 - A breakdown of sediment remediation projects in Great Lakes Areas of Concern.

EA OF CONCERN	CONTAMINATED SEDIMENT REMEDIATION PROJECT(S)
stique River	• In 1995-1996, approximately 14,000 m^3 of Polychlorinated Biphenyl (PCB)-contaminated sediment near the North Bay/U.S. 2 Highway was removed and disposed of in a nearby landfill. The remainder of the PCB-contaminated sediment will be addressed by the end of 1998. When the final removal is completed, approximately 92,000 m^3 of contaminated sediment will have been dredged from the river and shipped off-site for disposal. The total project cost is estimated at $16 million.
r Menominee River	• In 1993-1994, approximately 11,500 m^3 of bulk paint sludge was removed by mechanical dredging and transported to a nearby Treatment, Storage, and Disposal facility. This was an emergency removal through administrative orders by the Michigan Department of Environmental Quality (MDEQ).
aukee Estuary	• In 1994, approximately 5,900 m^3 of PCB-contaminated sediment was removed from behind Ruck Pond Dam. Over 95% of the mass of PCBs was removed from the system as a result of this project. The total project cost was $7.5 million. • In 1991, approximately 570,000 m^3 of contaminated sediment with varying levels was isolated from the Milwaukee River by the removal of the North Avenue Dam. The cost involved with the isolation of the contaminated sediment was approximately $1,348,000.
kegan Harbor	• As a result of a 1989 Consent Decree, Outboard Marine Corporation (OMC) provided $20 million for remediation of PCB-contaminated sediment. No soils or sediment above 50 mg/kg PCBs remain onsite, except those within containment cells. Approximately 30,000 m^3 of contaminated sediment was dredged and placed in two separate containment cells.
d Calumet River	• From 1994 to 1996, LTV Steel dredged approximately 89,000 m^3 of contaminated sediment from a slip adjacent to Indiana Harbor. The total project cost was an estimated $14 million.
ngwood Harbour	• From 1992 to 1993, approximately 8,000 m^3 of contaminated sediment was removed from the shipyard slips and adjacent areas in the harbour using the Pneuma airlift system. The total project cost, which included partners from the Ministry of

	Environment and Energy, Canada Steamship Lines, Transport Canada, and the Town of Collingwood, was an estimated $650,000.
Rouge River	• The PCB-source area to Newburgh Lake (Evans Products Ditch Site) was recently addressed by the MDEQ with support from U.S. EPA. Completed in April 1997, approximately 7,300 m^3 of PCB-contaminated stream sediment was removed and transported for disposal at a landfill in Michigan and hazardous waste disposal facility in New York. The total project cost was approximately $500,000. • In 1997, PCB-contaminated sediment is being removed from an impoundment (Newburgh Lake) in the Upper Rouge River and placed in a secure landfill. By the end of the project, approximately 306,000 m^3 of PCB-contaminated sediment will be removed. The project is expected to be completed by July 1998. The total project cost is estimated at $11.8 million. • In 1986, 30,000 m^3 of zinc-contaminated sediment was removed from the Lower Branch of the Rouge River by mechanical dredging and placed in cell #5 of the Corps of Engineers' Pointe Mouille Confined Disposal Facility on southwestern Lake Erie. All dredging and disposal activities were completed at an approximate cost of $1 million.
River Raisin	• Starting in mid-July and running through the end of September 1997, Ford Motor Company in Monroe, Michigan removed approximately 20,000 m^3 of PCB-contaminated sediment in a hot-spot adjacent to the shipping channel. The PCB-contaminated sediment has been disposed of in a TSCA cell that was built on the property of the Ford Monroe Plant.
Black River	• In 1990, the USS/KOBE Steel Company removed over 38,000 m^3 of PAH-contaminated sediment from the Black River mainstem in the areas of the former coke plant outfall. The total project cost, which was funded entirely by USS/KOBE, was $1.5 million.
Hamilton Harbour	• In 1995, *in situ* capping used a layer of uncontaminated material to uniformly cover PCB-and PAH-contaminated sediment. The project was funded through the Great Lakes 2000 Cleanup Fund at a cost of $300,000. An additional $350,000 was provided by the National Water Research Institute to further monitor and evaluate the project. • From 1992 to 1994, there was *in situ* treatment of contaminated sediment in one industrial boat slip near the headwall area. Oxygen, iron oxide, and calcium carbonate were injected. This was a demonstration treatment to find the depth of contamination. The total project cost was estimated at $323,000.
St. Clair River	• In 1996, Dow Chemical removed several thousand cubic meters of pentachlorophenol-contaminated sediment. The removal took place about 1 km south of the Cole Drain, about 30 m offshore. The total project cost was estimated at $350,000.
Detroit River	• Removal of contaminated sediment in Monguagon Creek, a tributary to the Detroit River, was initiated in 1997. The project is funded largely by Elf Atochem North America Inc., with an estimated cost of $3 million. When the final removal is completed, approximately 12,250 m^3 of contaminated sediment will have been dredged from the creek. • In 1993, approximately 3,075 m^3 of contaminated sediment was removed by Wayne County near a marina by Elizabeth Park. The total project cost was

	estimated at $1.33 million.
gara River	• In 1995, approximately 10,000 m^3 of contaminated sediment was removed from the Welland River (Ontario) using an Amphibex dredge. The total project cost was estimated at $2.6 million. • In 1996, approximately 21,800 m^3 of contaminated sediment was removed from the 102nd Street Embayment (New York). • In 1995, approximately 11,500 m^3 of contaminated sediment was removed from Pettit Flume (New York). • In 1992, approximately 6,100 m^3 of contaminated sediment was removed from Gill Creek (New York). The total project cost, which was funded entirely by DuPont, was approximately $10 million. • In 1990, approximately 13,000 m^3 of dioxin-contaminated sediment from Black and Bergholtz Creeks (New York) was removed. The total project cost was approximately $14 million.
Lawrence River	• The New York portion of the AOC involves three major large industrial sites. Ongoing remediation projects, as required by New York State and U.S. EPA, address land-based and contaminated river sediment. Some land-based projects involve shoreline and on-site wetland remediation. The contaminated river sediment projects at each industry include: • **General Motors** - During the summer of 1995, GM completed the major portion of its St. Lawrence dredging with the removal of approximately 11,500 m^3 of PCB contaminated river sediment. The river work to date has cost $10 million. The extent of required treatment and disposal for the dredged materials is under review. Further river sediment remediation in a cove adjacent to the St. Regis Mohawk Tribe remains to be completed. Total project costs, including land-based actions with groundwater recovery and treatment, are estimated to cost as much as $70 million. • **Reynolds Metals** - The required contaminated river sediment removal project for the St. Lawrence River has not yet begun. This will include shoreline remediation. The land-based plant site remediation, which includes wetlands remediation, is nearing completion at a cost of $53.7 million. The contaminated river sediment work is estimated to cost an additional $57 million. • **ALCOA** - The major "hot-spot" at the plant outfall in the Grasse River was remediated in 1995 as part of a 'non-time critical removal action." This involved the removal of approximately 3,000 m^3 of PCB contaminated river sediment. The results of this project are under review as is the feasibility of other remedial alternatives downstream from the outfall in the Grasse River up to the St. Lawrence River confluence. Major land-based inactive hazardous waste site remediation at the ALCOA plant site continues with 10 of the 14 Record of Decision sites now completed. Overall remediation costs are estimated to be in excess of $250 million.

ere have been 24 sediment remediation projects undertaken in 14 different Areas of Concern.*

***B* - A summary of the status of contaminated sediment management actions in Great Lakes Areas of ern (1997).**

Decision Made-Action Taken	Decision Made-Natural Recovery Underway	Decision Made-Action Pending

- Manistique River
- Lower Menominee River
- Sheboygan River
- Milwaukee Estuary
- Waukegan Harbor
- Grand Calumet River/Indiana Harbor Ship Canal
- * Collingwood Harbour
- Rouge River
- River Raisin
- Black River
- Hamilton Harbour
- St. Marys River
- St. Clair River
- Detroit River
- Niagara River
- St. Lawrence River

- Peninsula Harbour
- Jackfish Bay
- Nipigon Bay
- Torch Lake
- Deer Lake
- Severn Sound
- Spanish Harbour
- Presque Isle Bay
- Wheatley Harbour
- Bay of Quinte
- Metro Toronto and Region

- Thunder Bay
- St. Louis River/Bay
- Manistique River
- Grand Calumet River/Indiana Harbor Ship Canal
- Saginaw River/Bay
- Maumee River
- Ashtabula River
- Hamilton Harbour

Under Assessment-Decision Required

Thunder Bay
St. Louis River/Bay
Lower Menominee River
Lower Green Bay and
ox River
Sheboygan River
Milwaukee Estuary
Waukegan Harbor
Grand Calumet
ver/Indiana Harbor Ship
anal

- Kalamazoo River
- Muskegon Lake
- White Lake
- Saginaw River/Bay
- Clinton River
- Rouge River
- River Raisin
- Maumee River

- Black River
- Cuyahoga River
- Buffalo River
- Eighteen Mile Creek
- Rochester Embayment
- Oswego River
- Bay of Quinte
- Port Hope Harbour

- Metro Toronto and Region
- Hamilton Harbour
- St. Marys River
- St. Clair River
- Detroit River
- Niagara River
- St. Lawrence River

ndicates the AOC is delisted

***ble C* - A summary of contaminated sediment management actions taken in Great Lakes Areas of oncern, with identification of major obstacles to further action.**

These obstacles were identified by a key RAP representative from each jurisdiction. These determinations do not cessarily represent the views of others (federal agencies, Public Advisory Committees, etc.) working on these ojects.

Area of Concern	*Contaminated Sediment Management Action(s)*	*Limited Funding & Resources*	*Regulatory Complexity*	*Lack of a Decision-making Framework*	*Limited Corporate Involvement*	*Insufficient Research & Technology Dev't*	*Limited Public & Local Support*	*Comments*
Peninsula Harbour	• Source control has been implemented at the James River Marathon Mill and natural	•				•		Hg deposit lies under 60 m of

	recovery is anticipated for Hg-contaminated sediment.							water, precluding application of cost-effective technology. Zone impaired represents less than 10% of the Area of Concern (AOC).
ackfish Bay	• Possible removal of several thousand cubic meters of sediment from "Lake C." Possible capping of the highest zone of Hg contamination. Source control implemented at Kimberly Clark, and natural recovery is anticipated.	•		•				Lake C represents less than 10% of the AOC.
ipigon Bay	• Source control has been implemented at Domtar and natural recovery is anticipated.							Public acceptance of natural recovery, and industrial effluent controlled. Zone impaired represents less than 1% of the AOC.
hunder Bay	• Removal of contaminated sediment is expected at Northern Woods (for the zone that elicits lethality in the laboratory). Containment of contaminated sediment and natural recovery is expected for sublethal zone. There is a possibility of further cleanup of Hg-contaminated sediment at Provincial Papers.	•			•			Removal at Northern Woods estimated at 20,000-30,000 m^3. Several thousand at Provincial Papers. Remainder of AOC will rely on natural recovery. Zones for active remediation represent less than 10% of the AOC.
t. Louis iver-Bay	• From 1917 to 1979, the U.S. Steel Corporation (USS) disposed of large amounts of coal tars in Steel Creek which runs adjacent to the USS facility and empties into the St. Louis River. USS has proposed to build an earthen berm around highly concentrated coal tars and then solidify the wastes in place. After solidification, the area would be capped. The Minnesota Pollution Control Agency (MPCA) believes that this remedy will protect the St. Louis River. If there are no administrative problems, this remedial action should be completed sometime during the summer of 1997. • The Wire Mill Pond received wastewater	•			•	•	•	Contaminated sediment in delta areas of the St. Louis River lie outside the Wire Mill Pond and Steel Creek, and are highly contaminated when compared to risk based sediment quality criteria. The MPCA has determined that the hot spot areas in these deltas need to

	from their wire mill and other USS operations. The bottom of the pond is covered with 1-2 meters of oily waste. Other contaminants include polynuclear aromatic hydrocarbons (PAHs), cyanide, and other metals (including mercury). The MPCA has informed USS that the contaminated sediment must be removed. In response, USS has proposed to excavate and dispose of approximately 7,700 m^3 of contaminated sediment from the Wire Mill Pond during the summer of 1997 and place the sediment in a landfill. After excavation, the pond will be filled and re-established as a wetland. • Under an agreement with the Wisconsin Department of Natural Resources (WDNR), Murphy Oil USA has agreed to remove 75 m^3 of material from Newton Creek and 1,850-3,150 m^3 of contaminated sediment from a spill containment impoundment. The material will be combined with cement and placed in two existing Murphy Oil waste water lagoons. Stage two of the project will then focus on the clean up of petroleum-contaminated sediment in Hog Island Inlet.							be addressed. These areas continue to be eroded due to near shore wave action and are not being capped by natural sedimentation processes. USS has not clearly committed to addressing the sediment issue and the MPCA is considering further administrative and/or enforcement actions.
Torch Lake	• No action alternative (i.e. source control and natural recovery) was chosen under Superfund process.						•	Efforts have been made to stabilize and revegetate stampsands surrounding lake.
Deer Lake	• Source control and natural recovery was chosen through a Consent Judgement process. • Deer Lake was drawn down in 1984 and remaining fish killed with rotenone in 1986. Lake was refilled in 1987 and restocked with fish later that year.	•					•	
Manistique River	• In 1995-1996, approximately 14,000 m^3 of polychlorinated biphenyl (PCB)-contaminated sediment near the North Bay/U.S. 2 Highway area of the Manistique River was removed, dewatered and disposed of in a nearby landfill. The remainder of the PCB-contaminated sediment will be addressed by the end of 1998. When the final removal is completed, approximately 92,000 m^3 of	•			•	•	•	Zone remediated represents approximately 15% of the problem in the AOC.

	contaminated sediment will have been dredged from the river and shipped off-site for disposal. The total project cost is estimated at $16 million.							
ower Menominee iver	• Remediation of a site contaminated by submerged paint sludge was accomplished in 1993-1994 through administrative orders by the Michigan Department of Environmental Quality (MDEQ). The site is approximately 3.2 km north of the Menominee River in the nearshore waters of Green Bay. Approximately 11,500 m^3 of bulk paint sludge was removed by mechanical dredging and transported to a nearby Treatment, Storage, and Disposal facility. • Investigation of a site contaminated from historical operation of a manufactured gas plant is underway. • The largest site, contaminated by arsenic, is being addressed through a U.S. Environmental Protection Agency (U.S. EPA)-Resource Conservation and Recovery Act Corrective Action Order. The scope of the remedial investigation/feasibility study is being discussed with the Ansul Chemical Company. It is expected that approximately 11,500 m^3 of arsenic-contaminated sediment will be removed from the Eighth Street Slip by early 1998.		•	•	•		•	The removal of paint sludge created a substantial amount of residue. Researchers are currently testing and quantifying the residue to see if further remediation is necessary.
ower Green ay and Fox iver	• U.S. EPA and the WDNR, in concert with the local Remedial Action Plan (RAP) committees, developed a PCB/sediment transport model for this system. The output of this management tool provided the foundation for the Fox River Coalition, created to develop a whole river management strategy for contaminated sediment in this AOC. Currently, it is estimated that 8.4 million m^3 of contaminated sediment will need to be remediated. A coalition of industries have committed to a demonstration project in the lower river and the state has taken the lead on one upriver site. Both will be accomplished by 1999.	•	•		•			The Harbor Commission has received approval for a beneficial re-use of the material for highway project demonstration areas.
heboygan iver	• Emergency removal of 4,100 m^3 of PCB-contaminated sediment in the upper		•	•	•			The Sheboygan River has been divided into 3

	portion of the Sheboygan River was completed in 1991. Dredged sediment was placed in two Confined Disposal Facilities (CDFs), one temporary and the other an experimental CDF at Tecumseh Products Company. The remaining sediment will be dealt with in a final action under Superfund. • The U.S. EPA conducted several contaminated sediment studies and a pilot-scale demonstration of a treatment technology under the Assessment and Remediation of Contaminated Sediment (ARCS) program.							sections: The up-river section contains 13,000 m^3 of contaminated sediment. The lower section and harbor contains an estimated 1,000,000 m^3 of sediment with varying levels of contamination, and the middle section has not been adequately assessed. The Superfund Record of Decision (ROD) is to be issued by December 1997.
Milwaukee Estuary	• In 1994, approximately 5,900 m^3 of PCB-contaminated sediment was removed from behind Ruck Pond Dam. Non-Toxic Substances Control Act (TSCA) material (<50 mg/kg) was disposed of in a solid waste landfill approximately 64.4 km away. The TSCA material (>50 mg/kg) was sent to a TSCA landfill in Utah. Over 95% of the mass of PCBs was removed from the system as a result of this project. The total project cost was an estimated $7.5 million. • In 1991, approximately 570,000 m^3 of contaminated sediment of varying levels was isolated from the Milwaukee River by the removal of the North Avenue Dam. Channel stabilization and solidification of the mudflats has provided an interim remediation of this site. The cost involved with the isolation of the contaminated sediment was approximately $1,348,000.			•	•		•	Ruck Pond is the uppermost PCB-contaminated area on Cedar Creek, an upstream tributary to the Milwaukee River. Work is continuing with responsible parties to address the continuing problems in Cedar Creek.
Waukegan Harbor	• As a result of a 1989 Consent Decree, Outboard Marine Corporation (OMC) provided $20 million for remediation of PCB-contaminated sediment. Sediment in excess of 500 mg/kg PCBs from Slip #3 (a "hot spot" that accounts for the majority of PCBs on site) was removed (approximately 5,000 m^3) and PCBs thermally extracted onsite in 1993. Treated sediment was	•	•					Inner harbor maintenance dredging has not been performed since 1969. United States Army Corps of Engineers (USACE) Confined Disposal

	placed in a containment cell. Approximately 25,000 m^3 of harbor sediment was dredged and put in another containment cell. Soils in excess of 10,000 mg/kg PCBs were excavated and treated onsite by thermal extraction. Extracted PCBs were transported to an offsite facility for high-temperature combustion in accordance with TSCA requirements. No soils or sediment above 50 mg/kg PCBs remain onsite, except those within containment cells. Containment cells are operated and maintained by OMC.							Facility Draft Letter Report and Environmental Impact Statement are pending.
rand lumet ver/Indiana rbor Ship nal	• The U.S. EPA and Indiana Department of Environmental Management have reached settlements with a number of industries and municipalities in the Grand Calumet River basin for a variety of permit violations and other offenses. These settlements include either performing cleanup dredging or contributing a set amount of funds to be used for sediment cleanup. The total value of settlements is in the range of $100-200 million. Thus far, the only dredging that has been completed is by LTV Steel, which between the years 1994 to 1996, removed approximately 89,000 m^3 of contaminated sediment from a slip adjacent to Indiana Harbor. The total project cost of the remediation was an estimated $14 million. • U.S. EPA and USACE are working together on a comprehensive sediment remediation project to remove approximately 3,825,000 m^3 of contaminated sediment from the Indiana Harbor Ship Canal. The draft management plan, called an Environmental Impact Statement, is completed and it should be released for a public comment period in the Fall 1997. A CDF has been proposed to handle both sediment from navigational dredging and environmental remediation. • The U.S. EPA conducted several contaminated sediment studies and a pilot-scale demonstration of a treatment technology under the ARCS program.	•	•		•	•	•	
lamazoo ver	• Approximately 159,000 kg of PCBs contaminate a 128 km reach of the Kalamazoo River from the City of	•	•		•	•	•	This AOC represents the largest source of

	Kalamazoo to Lake Michigan. This contaminated sediment problem is under assessment and litigation. MDEQ has entered into a consent agreement with the Potentially Responsible Parties (PRPs) to undertake the remedial investigation and feasibility study. U.S. EPA Superfund recently conducted a removal assessment of the Bryant Mill Pond. The removal assessment report will be completed by the Summer of 1997 and will contain a recommendation regarding potential removal responses.							PCBs entering Lake Michigan from Michigan tributaries.
Muskegon Lake	• The severity and geographic extent of the contaminated sediment problem is under assessment.	•		•			•	Still collecting information on the site.
White Lake	• The severity and geographic extent of the contaminated sediment problem is under assessment.	•		•			•	Still collecting information on the site.
Saginaw River/Bay	• The Natural Resource Trustees (both federal and state) are completing an agreement with the PRPs to settle a natural resource damage claim, which will include the removal of approximately 222,500 m^3 of PCB-contaminated sediment. An Agreement in Principal was reached with the PRPs in February 1997 which has allowed certain options to be exercised for the purchase of lands for habitat enhancement and restoration. The planning and design phase for the sediment remediation project is underway. Dredging is expected to begin in 1998. • The U.S. EPA conducted several contaminated sediment studies and a pilot-scale demonstration of a treatment technology under the ARCS program.		•	•				Legal complexities and arguments have delayed cleanup for at least three years.
Collingwood Harbour	• From 1992 to 1993, approximately 8,000 m^3 of contaminated sediment from the shipyard slips and adjacent areas in the harbour was removed using the Pneuma airlift pumping system. The project involved two phases, the first beginning in November 1992 at the west boat slip with additional removal at the eastern dry dock. The total amount of contaminated sediment removed from the west boat slip and eastern dry dock was approximately 5,000 m^3. The second phase of the project							Public support resulted in corporate involvement. Sediment in the remainder of the AOC is not contaminated. Zone remediated represents less than 1% of the AOC.

	involved removal from the inner harbour in November 1993. Contaminated sediment removed from the inner harbour was approximately 3,000 m^3. The sediment from both phases of removal was transported through a pipeline to a CDF 1.2 km away. The total project cost, which included partners from the Ministry of Environment and Energy, Canada Steamship Lines, Transport Canada, and the Town of Collingwood, was approximately $650,000.							
evern ound	• Several thousand cubic meters of wood fiber was removed in the mid-1990's. No further action is proposed.							Sediment that has contaminants above provincial guidelines does not elicit chronic toxicity, no action required.
panish arbour	• Source control based on loading reductions from atmospheric emissions is the preferred strategy since sediment elicits marginal chronic toxicity.							Source of metals are from outside the AOC and levels are declining with emission reductions in conjunction with Countdown Acid Rain. Zone of contamination represents approximately 20% of the AOC.
linton River	• The severity and geographic extent of the contaminated sediment problem is under assessment.			•			•	Combined sewer overflow's are a problem; in addition, there are several other potential sources of concern including industrial and households. Nonpoint sources are also a concern (copper, fertilizers/nutrients, heavy metals, fecal coliform).
ouge River	• The PCB-source area to Newburgh Lake (Evans Products Ditch Site) was recently	•	•	•	•	•	•	Sediments are a hidden problem,

	addressed by MDEQ with support from U.S. EPA. Completed in April 1997, approximately 7,300 m^3 of PCB-contaminated stream sediment was removed and transported for disposal at a landfill in Michigan and hazardous waste disposal facility in New York. The total project cost was approximately $500,000. • In 1997, PCB-contaminated sediment is being removed from an impoundment (Newburgh Lake) in the Upper Rouge River and placed in a secure landfill. By the end of the project, approximately 306,000 m^3 of PCB-contaminated sediment will be removed. The project is expected to be completed by July 1998. The total project cost is estimated at $11.8 million. • In 1986, approximately 30,000 m^3 of zinc-contaminated sediment was removed from the Lower Rouge River by mechanical dredging and placed in cell #5 of the Corps of Engineers' Pointe Mouilee CDF on southwestern Lake Erie. All dredging and disposal activities were completed at an approximate cost of $1 million.							not apparent to the public. Zone remediated represents less than 10% of the problem in the AOC.
River Raisin	• Starting in mid-July and running through the end of September 1997, Ford Motor Company in Monroe, Michigan removed approximately 20,000 m^3 of PCB-contaminated sediment in a hot-spot adjacent to the shipping channel. The PCB-contaminated sediment has been disposed of in a TSCA cell that was built on the property of the Ford Monroe Plant.	•	•				•	
Maumee River	• A cleanup is underway to remove PCB-contaminated sediment from a tributary to the Ottawa River. This should eliminate a major source of contaminants to the Ottawa River.	•	•	•	•	•	•	The Toledo Harbor Planning Group, composed of state, federal, and local government agencies, was established in 1992 to develop a long-term dredged material management plan for the river. Many other small tributaries also contain

								contaminated sediment, but have not yet been adequately assessed for appropriate remedial action.
ack River ain stem)	• In 1990, the USS/KOBE Steel Company removed over 38,000 m^3 of PAH-contaminated sediment from the Black River mainstem in the areas of the former coke plant outfall. The sediment was placed in a secure landfill on USS/KOBE property. The total project cost, which was funded entirely by USS/KOBE, was $1.5 million.							A number of agricultural best management practices are underway throughout the watershed to reduce sediment runoff. Biotechniques have been installed in at least three sites in the watershed with another three planned for 1997.
yahoga ver	• The issue here is more than just one of dredging contaminated sediment. The ship channel is a very deep, narrow channel, and the alteration in stream morphology has created a situation of low flow and little opportunity for reaeration. During periods of high temperature and low flow, the bottom waters in the channel will have dissolved oxygen below water quality standards. This has created a complicated regulatory issue between U.S. EPA, Ohio EPA, USACE, and shippers and dischargers in close proximity to the channel. The Cuyahoga RAP has become very involved in assisting to develop a plan to determine how to meet water quality standards.							Although the Cuyahoga RAP has identified contaminated sediment as an issue, there is no organized sediment remediation or reduction plan. Over the years, the concentrations of contaminants in the sediment and the amount of sediment itself have been significantly reduced. Overall efforts to reduce the amount of pollutants entering the river, such as: more restrictive National Pollutant Discharge Elimination System permits; elimination of discharges as

								companies close, change processes or tie into municipal wastewater treatment plants; various programs to reduce air emissions; stormwater controls; etc. continue to improve the quality of the sediment.
Ashtabula River	• A longterm, comprehensive management plan has been developed to address where, what, and how much to dredge from the river, and where it will go. After considerable review, several potential disposal sites have been selected and CDF design is underway. • The U.S. EPA conducted several contaminated sediment studies and a pilot-scale demonstration of a treatment technology under the ARCS program.	•	•	•		•		In 1994, the Ashtabula River Partnership (ARP) was formed with the specific goal of dredging contaminated sediment from the river. This action was initiated by local corporate leadership as an alternative to probable Superfund action. The ARP has been very successful in raising resources and building local support. Much has been accomplished, but many issues still need to be addressed.
Presque Isle Bay	• Source control is being implemented under a Consent Decree resulting in upgrades of the Publically Owned Treatment Works which will double capacity, improve treatment, provide for a 18,185,000 liter (4 million gallon) overflow retention facility, and eliminate the remaining 40 CSOs in the city of Erie. These efforts, along with nonpoint source control measures, should allow for natural recovery of the system.	•		•				Decision to allow for natural recovery will be determined by the Public Advisory Committee based on defensible scientific analysis in conjunction with community held social and economic

								considerations.
heatley rbour	• Maintenance dredging, source control and natural recovery for PCBs.							PCBs are above open water disposal guidelines for the entire AOC but elicit no chronic toxicity.
ffalo ver	• U.S. EPA completed a 5-year ARCS program for control/removal of sediment. Mass balance modeling in conjunction with loading and risk assessments were applied.	•				•		Strategies to remediate contaminated sediment need to be defined. U.S. EPA is developing sediment criteria that will assist decision-making.
ghteen le Creek	Strategies call for the development of sediment criteria to identify use impairment causes, and then to define remedial plans considering sediment removal/armoring alternatives. • The New York Barge Canal needs a study to determine impact, contaminant sources, and any remedial strategy. • Great Lakes National Program Office is funding a sediment core study in Eighteen Mile Creek in 1997.	•				•		Sediment characterization for PCBs, dioxins, and metals is planned by the New York State Canal Corporation.
chester bayment	• At the request of Monroe County and New York State Department of Environmental Conservation (NYSDEC), the USACE has restricted overflow dredging in the Rochester Harbor. Any use impairment is unknown; further assessment of sediments is needed.	•				•		Unloading cement at Rochester remains the primary reason for deep dredging of the harbor area.
wego ver	• Maintenance dredging for shipping by the U.S. Army Corp of Engineers is currently considered not impaired; sediment study results are under review. The severity and geographic extent of any contaminated river sediment problem or expanded dredging plan needs further assessment.	•				•		USACE testing indicates open lake disposal of dredge material is appropriate. NYSDEC approval pending.
y of inte	• Sediment cleanup at federal facilities is anticipated. Source control and natural recovery of bay sediment is expected.							Contaminants in sediment are principally nutrients, and in most of the AOC do not cause

								toxicity problems. Zone of impairment represents about 25% of the AOC.
Port Hope Harbour	• Removal of sediment that has low level radioactive waste has been recommended, but has not yet occurred.		•					Until the low level siting task force has selected a site for containment of soils and sediment, there will be no action.
Metro Toronto and Region	• Demonstration project occurred in the inner harbour. Source control (particularly for combined sewer overflows and sewage treatment plants) leading to natural recovery is the predominant management action.	•				•		Abatement of point and non-point sources requires very large infrastructure expenditures, slowing the process of natural recovery considerably. These inputs effect depositional zones in most of the AOC.
Hamilton Harbour	• *In situ* sediment capping used a layer of uncontaminated material, acceptable for unrestricted open-water disposal, to uniformly cover PCB- and PAH-contaminated sediment that elicits chronic toxicity. Full-scale capping began in August 1995. The cap layer, comprised of clean medium to coarse sand, was spread evenly in 3 m wide layers with a 1 m overlap. Areas of 5 m by 100 m were covered with 450 tonnes of sand under optimum conditions over a 10 hour day. The average cap thickness was approximately 30 cm. The entire 1 ha cap was in place by September 1995. The project was funded through the Great Lakes 2000 Cleanup Fund at a cost of $300,000. An additional $350,000 was provided by the National Water Research Institute to further monitor and evaluate the project. • From 1992 to 1994, there was *in situ* treatment of contaminated sediment in one industrial boat slip near the headwall area.	•		•	•	•		Costly technology precludes cleaning up a larger zone. Roughly 75% of the sediment in the harbour elicits at chronic toxicity. The zone for sediment removal is less than 5% of the AOC.

	Oxygen, iron oxide, and calcium carbonate were injected. This was a demonstration treatment to find the depth of contamination. The total project cost was $323,000. • Proposed removal of 20,000-30,000 m^3 of PAH-contaminated sediment is expected to begin in 1998 at the Randle Reef. Negotiations are underway with potential partners to fund the remediation. Small scale demonstration projects have been conducted. Source control and natural recovery proposed for remainder of harbour.							
Marys er	• Demonstration projects removed several hundred cubic meters of sediment and tested *in situ* treatment. Final strategy still to be developed and likely to include further sediment removal targeted at PAHs and metals.	•		•	•			
Clair er	• In 1996, Dow Chemical removed several thousand cubic meters of pentachlorophenol-contaminated sediment. The removal took place about 1 km south of the Cole Drain, about 30 m offshore. The total project cost was estimated at $350,000.	•		•				Zone of toxicity substantially reduced due to source control. If further removal is implemented, it will occur in less than 10% of the AOC.
roit River	• Removal of contaminated sediment in Monguagon Creek, a tributary of the Detroit River, was initiated in January 1997. The project is funded largely by Elf Atochem North America Inc., with an estimated cost of $3 million. The creek will be divided into sections so that water will be removed from one section at a time for the removal of sediment. Contaminated materials will be taken to BFI Arbor Hills Landfill in Northville Township, Michigan. When the final removal is completed, approximately 12,250 m^3 of contaminated sediment will have been dredged from the creek. • In 1993, approximately 3,075 m^3 of contaminated sediment was removed by Wayne County near a marina by Elizabeth Park. The contaminated sediment was disposed of at an upland site. The total project cost was estimated at $1.33 million.	•	•	•	•	•	•	

Niagara River	• In the Welland River (Ontario), approximately 10,000 m^3 of contaminated sediment was removed in a 1995 dredging project using an Amphibex dredge. A silt curtain was used during removal to minimize dispersal. All dredged material was placed in a designated discharge area. The total project cost was estimated at $2.6 million. • U.S. EPA and NYSDEC are overseeing remediation at three locations along the Niagara River that are considered sources of contaminants causing use impairments in the river (i.e. mouth of Pettit Flume; 102nd Street embayment; and the mouth of Gill Creek). Remedial actions on the 102nd Street Embayment were completed in 1996 with approximately 21,800 m^3 of contaminated sediment removed. Remedial actions on Pettit Flume were completed in 1995 with approximately 11,500 m^3 of contaminated sediment removed. Remedial actions on Gill Creek were completed in 1992 with approximately 6,100 m^3 removed. The total cost of the Gill Creek project, which was funded entirely by DuPont, was approximately $10 million. • In 1990, approximately 13,000 m^3 of dioxin-contaminated sediment from Black and Bergholtz Creeks (New York) was removed and stored at Occidental's Buffalo Avenue Plant. Occidental has set up a high temperature (>2,200F) incinerator for the waste, and ash will be stored on-site. The total project cost was approximately $14 million.	•	•	•		•		Cleanup in Ontario was based on the zone where biological testing revealed toxicity problems. Zone remediated represents less than 10% of the AOC. What is learned from the Buffalo River ARCS program can be applied to the Niagara River. Sediment Criteria are again needed for the decision-making process.
St. Lawrence River	• The New York portion of the AOC involves remedial action plans at the three major industrial sites: General Motors, Reynolds Metals, and ALCOA. Ongoing remediation projects, as required by New York State and U.S. EPA, address land-based and contaminated river sediments. Some land-based projects involve shoreline and on-site wetland remediation. The required contaminated river sediment projects at the three industries are designed such that one facility's investigative and remedial responsibility takes over where another facility's responsibility ends. Therefore, all major contaminated river	•	•	•		•		U.S. EPA issued orders to the three major industries in the Area of Concern to address contaminated river sediments. EPA orders include the land-based activities at General Motors. NYSDEC is assisting in the oversight of river dredging and has

sediment areas are addressed under one of the federal administrative orders. Remedial projects include:

- **General Motors** - During the summer of 1995, GM completed the major portion of its St. Lawrence dredging with the removal of approximately 11,500 cu.m. of PCB contaminated river sediments. The river work to date has cost $10 million. The extent of required treatment and disposal for the dredged materials is under review as part of a Record of Decision modification. Further river sediment remediation in a cove adjacent to the St. Regis Mohawk Tribe remains to be completed. Total project costs, including land-based remediation could approach $70 million; $26 million has been spent to date for PCB cleanup.
- **Reynolds Metals** - The required contaminated river sediment removal project for the St. Lawrence River has not yet begun. This will include shoreline remediation. The land-based wetlands projects and plant site remediation are nearing completion at a cost of $53.7 million. Site work included wetland restoration. The contaminated river sediment work is estimated to cost an additional $57 million.
- **ALCOA** - The major "hot-spot" at the plant outfall in the Grasse River was remediated in 1995 as part of a 'non-time critical removal action." This involved the removal of approximately 3,000 cu.m. of PCB contaminated river sediments and accounts for 25% of the PCB contamination in the Grasse River. The results of this project are under review as is the feasibility of other remedial alternatives downstream from the outfall in the Grasse River up the St. Lawrence River confluence. Major land-based inactive hazardous waste site remediation at the ALCOA plant site continues with 10 of the 14 Record of Decision sites now completed. Site work includes remediating lagoons and wetland restoration. Overall remediation costs are estimated to be in excess of $250 million.

also issued orders to address the land-based remediation at ALCOA and Reynolds Metals. Reynolds Metals has nearly completed its land-based remediation; ALCOA has completed 10 of 14 land-based hazardous waste sites; and, the General Motors on site landfill has been temporarily capped. U.S. EPA is considering Record of Decision (ROD) modifications for the treatment and disposal of dredge materials at General Motors and Reynolds Metals. The ROD modification decision will establish the remediation requirements for the dewatered dredge materials stockpiled on the GM site as well as the treatment and disposal of land-based contaminated soils at General Motors. Reynolds Metals plans to begin its St. Lawrence River dredging remediation in 1998.

Primary use impairments that need to be resolved in the AOC are fish and wildlife

								consumption restrictions, degradation of fish and wildlife habitat, and transboundary impacts (e.g. downstream considerations of the St. Regis Mohawk Nation at Akwesasne). The three large major industrial remediation projects are designed to address these use impairments. Once the remediation activities have been completed, these use impairments will need to be monitored and reassessed to determine if further impact is present and if any further remedial action is needed.

Table D **- Preliminary assessment of obstacles to sediment remediation based on input from local, state, provincial, and federal officials.**

OBSTACLES	TOTAL NUMBER OF AOCs
Limited Funding and Resources	28
Regulatory Complexity	15
Lack of a Decision-Making Framework	18
Limited Corporate Involvement	14
Insufficient Research and Technology Development	17
Limited Public and Local Support	19

*** Totals based on 42 AOCs**

URL: http://www.ijc.org/boards/wqb/sedrem.html